CITRUS-FRUIT IMPROVEMENT

How to Secure and Use Tree-Performance Records.

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CITRICULTURE

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HOW TO SECURE AND USE TREE-PERFORMANCE RECORDS

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Contribution from the Bureau of Plant Industry
WM. A. TAYLOR, Chief

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MANY California citrus growers have reported in recent years that they were securing lower yields of fruit per acre than in the earlier history of their industry. Complaint also has been made that an increasing proportion of the fruit of the leading commercial varieties of oranges and lemons was abnormal or "off type" in size, form, color, smoothness of skin, or other important characteristics.

Systematic and continued investigation of this subject in the groves in California since 1909 has disclosed that a considerable proportion of the deterioration observed is traceable to unintentional propagation of undesirable strains of the leading varieties resulting from bud variation.

The results obtained in bud-selection experiments carried on during the past five years indicate that by top-working with buds from those having consistently good records for productiveness and quality the inferior or "drone" trees of such varieties as Washington Navel and Valencia oranges can be made productive and profitable.

This bulletin describes the methods that have been found effective and practicable in locating the desirable and undesirable trees in groves and for transforming the latter when found.

CITRUS-FRUIT IMPROVEMENT: HOW TO SECURE AND USE TREE-PERFORMANCE RECORDS.

CONTENTS.

INTRODUCTION.

The established and proved citrus varieties are the most valuable possession of the citrus industry. The conservation, standardization, and stabilization of these varieties should receive most careful consideration by citrus propagators and growers.

The deterioration or "running out" of these varieties through the unintentional propagation of undesirable strains is responsible for a large proportion of the low yields of inferior fruits in many citrus orchards. The introduction of new varieties to take the place of those which have become unprofitable by reason of the use of careless methods of propagation is usually a matter of experiment. The establishment of new varieties requires long periods of time to prove their value to the grower and to introduce them in the markets.

The use of individual-tree records of production in citrus orchards was originally introduced into California by the writer in 1909. The utility of such records as a factor in the practical work of standardizing the quality and quantity of fruit production in established orchards has been proved experimentally and tested commercially. As a result of these investigations thousands of nursery trees have been propagated and inferior trees in established orchards top-worked with buds selected from productive trees of desirable strains on the basis of their performance records for a series of years. Several thousand of these trees have come into bearing, and as far as can be determined from trees of their age they have without exception reproduced the strain which was propagated.

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The data secured during a 6-year investigation of the nature and amount of bud variability occurring in Washington Navel orange trees in California will be presented and interpreted in another publication of the United States Department of Agriculture. The methods of commercial orchard practice recommended here are based on the results of that investigation.

The importance of individual-tree performance records as a basis for measuring the effects of cultural or other tree treatments, both in investigational and commercial work, has become so evident that such records are now regarded by the most efficient and successful California citrus growers as of great value in all orchard work. When making changes in methods of tree culture or care, the way to determine definitely whether such changes are of value is to secure performance records of the trees both before and after the new systems are put into practice. The increasing demand from growers for advice regarding a practical method of keeping individual citrus-tree performance records has made necessary the publication of this bulletin.

BUD VARIATION.

Although there is no generally accepted theory to account for bud variability in citrus trees, bud variation is of more or less frequent occurrence in trees of all varieties. It may manifest itself in the habit of growth of the trees or their method of branching, the size, form, texture, or color of the foliage, or the form, color, texture, abundance, or scarcity of the fruits. Occasionally one tree grown from a single bud will develop several distinct strains of fruit. Frequently a single fruit or a branch bearing several fruits will be found on a tree having characteristics distinct from the fruits of the typical strain borne by the tree as a whole. Minor variations in fruit characteristics are of very frequent occurrence.

Individual-tree performance records reveal the extent to which trees in commercial plantations differ from one another in their regularity of bearing and in the quality, quantity, and character of the fruit produced.

The nursery propagation of bud variations may be largely avoided through the use of buds selected from individual trees the performance records of which have shown them to be heavy annual producers of fruit of a desirable strain. Healthy citrus trees of inferior strains in established orchards may be successfully top-worked to the best strain and may thus convert into an asset what was formerly a liability of the orchard.

THE OBJECT OF PERFORMANCE RECORDS.

The object of securing individual citrus-tree performance records is to obtain reliable information as to the behavior of individual trees in established bearing orchards. This information may be utilized in the elimination of inferior or drone trees by top-working or removing them, in the selection and location of particularly good trees for use as sources of bud wood for propagation, in studying the results of individual tree treatments, and for other purposes where it is important to know definitely the amount and value of fruit production. Individual-tree performance records enable citrus growers to replace indefinite and oftentimes unreliable opinions as to orchard conditions by exact and definite information, from which safe conclusions may be drawn.

METHODS OF SECURING THE RECORDS.

TREE NUMBERS.

The first step in securing individual-tree performance records is to number each tree, so that the record of the trees may be kept during successive years without danger of confusion and mistakes in securing and entering the performance-record data and other notes.

The numbering system evolved in the investigation of this problem has been adopted by many citrus growers. It provides for giving each tree a number consisting of three sets of figures. This individual tree number is made up of the number of the block or division of the orchard, the number of the row in which the tree occurs, and the position of the tree in the row, counting always from some fixed point, such as the irrigation head; for instance, a tree located in block 2, row 4, and the tenth tree in the row will have the number 2-4-10.

The numbers can usually be painted on the tree trunk or on one of the main limbs. It has been found most convenient to place these numbers in a vertical column, and they are more easily read when arranged in this form. Pure white-lead paint and an ordinary lettering brush should be used for this work. The numbers should always be placed in the same relative position on all of the trees in an orchard, so that they may be easily found at any time. Where it is not possible to paint the number on the tree it can be painted or stamped on a wooden or metal tag, which should be attached to the tree where it can be easily seen and in such a manner as not to interfere with the future growth of the tree. Large plain figures should be used, so that the number can be read from some distance. One man can usually number 175 or more trees in a day.

This system will prevent the duplication of numbers, no matter how many blocks or trees there are in the orchard; it will locate any particular tree, so that it can be easily found at any time for individual-tree care, for the consideration of its performance record, or for other purposes; and it will promote accuracy and simplicity in recording individual-tree data.

It seems advisable, in order to secure uniformity and accuracy in tree numbers, to advise the members of associations of fruit growers to have the numbers painted on the trees by a regular crew managed by the association, as is the practice at the present time in picking the crops. It can doubtless be arranged by most associations to have some members of the regular picking crew attend to the tree-number work before the regular picking season begins or during a slack period in that season.

PICKING.

The organization of the picking crew should be such that one man picks the fruits of an individual tree. The crew can usually be organized so that each picker is assigned to a row of trees. This arrangement frequently induces some rivalry among the pickers and will usually result in more rapid and efficient work than has heretofore been the case. Where tree records are not kept, two or more pickers as a rule work on the same tree, but this practice is not desirable where performance records are to be secured.

The picking boxes should be distributed to the individual trees instead of being assembled in box rows. A little practice will enable the distributors of the boxes to determine about the number of boxes required to hold the crop of each tree.

The picker should always empty his picking sack after finishing each tree, so as to avoid carrying any fruits to the next tree. The boxes, after being filled, should be assembled in the shade of the tree from which the fruits were picked in order to protect them from the sun.

WEIGHING.

The crop of fruit of each pick from an orange or grapefruit tree can be expressed in terms showing the number of full and partly filled boxes borne by the tree. In the case of lemon or lime trees, where frequent picks are usually made from each tree, the amount of each pick can be expressed in a manner similar to that for orange and grapefruit trees or, as is usually done, by determining the actual weight of the fruits and recording the results in terms of pounds.

Many citrus growers who are keeping individual-tree records in their orchards have found that a record of the number of full boxes and the estimated amount of fruit in the partly filled boxes is suffi-

ciently accurate for their purposes. This method does away with the necessity for any apparatus for weighing the fruits. Where a considerable proportion of the crop of full-bearing trees is picked at one time this method of recording the amount of the yield of the individual trees will doubtless prove to be satisfactory. Where the amount of the pick from the trees is small, a more accurate record will be obtained by weighing the fruits.

A convenient method for determining the amount or weight of the fruit in the picking boxes is shown in figure 1. Figure 2 shows (at *A*) a shoulder harness, by means of which an inexpensive spring balance, *B*, is carried. The scale, *a*, provides for weighing a maximum of

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FIG. 1.—Weighing citrus fruits in picking boxes for individual-tree performance records.

50 pounds. The opposite scale, *b*, is calibrated by actual trials of empty and full picking boxes, the box tare being marked as 0 and the weight of a full box as 10. The space between these marks is divided into 10 equal parts, numbered from 1 to 10. Such an arrangement provides for determining the amount of the crop in the partly filled box either in terms of pounds or as tenth parts of boxes, as desired.

The ropes, *d*, are provided with steel hooks, *e*, so that they can be easily attached to the ends of the picking boxes. In using these scales the weigher attaches the hooks to the ends of the box, rises, assuming an upright position, thus lifting the box from the ground, and, with the box swinging free, reads the weight of the fruit.

A little experience with this balance will enable the weigher to secure accurate records of the amount of fruit in the picking boxes. In the case of a picking crew of 25 to 50 men the weigher will also have time to help inspect and distribute empty picking boxes, load the filled boxes on the orchard wagons, and perform such other duties as may be necsary to insure the careful handling of the boxes of fruit.

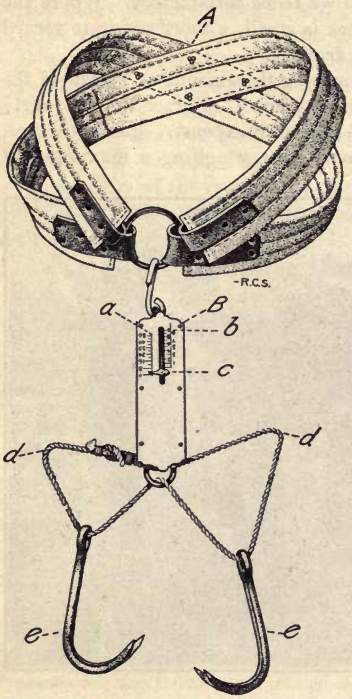

FIG. 2.—Details of the weighing apparatus shown in figure 1: *A*, Shoulder harness; *B*, spring balance; *a*, scale for weighing a maximum of 50 pounds; *b*, scale calibrated to indicate full box or parts of box in tenths; *c*, pointer; *d*, *d*, ropes; and *e*, *e*, steel hooks.

It has been found by experience that in order to secure reliable individual-tree records it is desirable to have one of the regular picking crew attend to this matter. In one large citrus planting, where individual-tree records have been kept for several years and the picking is done by crews of Mexican laborers, one Mexican in each crew keeps the records, inspects the empty picking boxes, and does such other work as is required in order to promote the careful handling of the fruits.

In other cases the foremen of the picking crews are expected to keep the individual tree records in addition to their other duties. This plan has been found to be less successful than where an extra laborer for each picking crew is provided for this purpose.

In association picking crews, where the crops of the individual members of the association are picked by a general picking crew, the individual-tree records can be secured in the smaller orchards by the simple expedient of adding one regular laborer to each picking crew. Any intelligent person can quickly learn how to keep the individual-tree records and assist in handling the fruits, so that the expense of the extra man can be justified from this standpoint.

RECORDING THE RESULTS.

The date of picking and the quantity and quality of the product of each tree should be recorded so that it can be easily classified and compiled for the intelligent consideration of that individual tree's behavior. The three forms shown herewith are suggested for the use of those who wish to keep such records. The successful use of similar forms in commercial performance-record keeping has proved their practicability. Experience with these forms has shown that a sheet of convenient size is one which provides space for recording the yields of 40 trees. These sheets should have a stiff-back loose-leaf cover or be perforated and bound in covers to facilitate their use in the orchard and to make it possible to assemble the records of any particular block.

The form recommended for keeping orange and grapefruit individual-tree performance-record data for a maximum of four picks in one season from each tree is shown in Table I, *A*.

The form recommended for use in keeping individual lemon and lime tree performance-record data, providing for a maximum of 12 picks each season, is shown in Table I, *B*. In this form provision is made for recording the quantity of fruit, either in terms of pounds or as the number of full and partly filled boxes, for a maximum of 12 picks from each tree during the season.

The commercial grade of the fruits of the individual trees can be recorded by the use of the following or a similar system: *A* may be used to designate the best or first-grade fruits; *B*, inferior, blemished, or second-grade fruits; *C*, cull or third-grade fruits; and *S*, extremely variable fruits as regards shape, size, color, or other characteristics. This system can be extended, if desired, to cover other matters of importance in individual-tree care, as, for instance, the letter *X*, to call attention to particularly good trees which may be found suitable for the selection of bud wood for propagation; *D*, to suggest diseased or injured trees; *F*, to mark such trees as may need fumigation; *P*, to show the need of pruning; *T*, to indicate an undesirable tree which should be top-worked or removed; and such other letters or symbols can be employed as may be of value in systematic individual-tree care.

TABLE I.—*Forms for keeping individual-tree performance records for citrus and similar fruits.*

[The three forms here reproduced as samples, marked respectively A, B, and C, are necessarily shown somewhat abridged as to number of trees, simply for economy of space. In actual use, each form is to occupy a full sheet, and a length sufficient to record the yields of 40 trees is recommended.]

FORM A.—ANNUAL TREE RECORDS OF ORANGE AND GRAPEFRUIT ORCHARDS FOR A MAXIMUM OF FOUR PICKS DURING THE SEASON.

Block No..... Age of trees..... Season..... Variety.....

Row No..... Trees per acre..... Grove..... Location.....

Tree.	Dates of picks.												Yield for season.		
	Boxes.	Part boxes.	Grade.	Boxes.	Part boxes.	Grade.	Boxes.	Part boxes.	Grade.	Boxes.	Part boxes.	Grade.	Total.	Average grade.	Notes.
No. 1															
No. 2															
No. 3															
No. 4															
No. 5															
No. 6															
No. 7															
No. 8															
No. 9															
No. 10															
No. 11															
No. 12															
No. 13															

FORM B.—ANNUAL TREE RECORDS FOR LEMON AND LIME ORCHARDS.

Block No..... Age of trees..... Season..... Variety.....

Row No..... Trees per acre..... Grove..... Location.....

Tree.	Dates of picks.												Yield for season.		
	Amt.	Amt.	Amt.	Amt.	Amt.	Amt.	Amt.	Amt.	Amt.	Amt.	Amt.	Amt.	Total.	Grade.	Notes.
No. 1															
No. 2															
No. 3															

FORM C.—PERIOD CITRUS-TREE RECORDS.

Block No..... Age of trees..... Season..... Variety.....

Row No..... Trees per acre..... Grove..... Location.....

Tree.	Season.												Total for .. years.			Treatment of tree or other notes.
	191...			191...			191...			191...						
	Boxes.	Part boxes.	Grade.	Boxes.	Part boxes.	Grade.	Boxes.	Part boxes.	Grade.	Boxes.	Part boxes.	Grade.	Boxes.	Part boxes.	Average grade.	
No. 1																
No. 2																
No. 3																
No. 4																

The data showing the total yield of each tree and the related notes should be transferred to a period citrus-tree record form, such as is shown in Table I, *C*. This form provides for bringing together the records of several successive seasons, so that the behavior of each tree during a given period may be studied and compared with that of other trees grown under similar conditions. The number of seasons' records necessary for this purpose varies somewhat according to the conditions, but in all cases an even number of seasons' records is desirable. As a rule, the records of full-bearing trees for two successive normal seasons have been found to be a sufficient basis for determining the relative value of individual citrus trees for commercial fruit growing. The records of four successive normal seasons will probably be adequate for use as a basis for the selection of parent trees as sources of bud wood for propagation. In any event two years' experience will demonstrate to every grower the importance of individual-tree records, from which he can easily draw his own conclusion as to length of the period he should keep these records. So far in the cooperative work of this character not a single grower has dropped the individual-tree record work after having started it, and some of the records now cover a period of six years.

THE USES OF PERFORMANCE RECORDS.

BUD-WOOD SELECTION.

Citrus bud wood for commercial propagation should be cut only from the best trees of the most valuable strain. These trees should be selected on the basis of their performance records and from intimate individual-tree knowledge.

Only fruit-bearing bud wood should be used for propagation. Every bud stick should have one or more typical fruits attached, if possible, when cut from the select parent trees, as shown in figure 3. By the use of this method more buds can be secured from productive and desirable trees than from unproductive and undesirable ones. Such bud wood has been found to produce trees of satisfactory growth, as well as early and regular yields of fruit.

In the past, sucker growth has been generally used for propagation, and little or no attention has been paid to the number or quality of the fruits borne by the trees from which bud wood has been secured. This practice has naturally led in many cases to the propagation of inferior strains. The large proportion of trees of undesirable strains in many citrus orchards is due to this lack of care in the selection of bud wood.

TOP-WORKING UNDESIRABLE TREES.

The elimination from established orchards of trees of undesirable strains has been effected by top-working these trees with select buds from trees of a desirable strain.

While trees of some of the inferior strains can be recognized from their habit of growth or other vegetative characteristics, it is desirable wherever possible to make the final selection of trees to be top-worked on the basis of their performance records and the characteristics of the fruits borne by them.

The selection of the bud wood for top-working purposes was based on individual-tree performance records and an intimate knowledge of tree characteristics secured by careful observation.

The first top-working on a commercial scale, as a result of the bud-selection investigations of the Department of Agriculture, was done in the summer of 1911. In a 235-acre orchard of 8-year-old Eureka lemon trees, approximately 2,500 trees of inferior strains

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FIG. 3.—Typical fruit-bearing citrus bud wood recommended for use in propagation.

were top-worked with buds from carefully selected trees in the same orchard.

Notwithstanding the extremely cold weather of the succeeding two winters, which very seriously injured the growth from these buds, the rebudded trees are at the present time as productive as the other trees in the orchard, and without exception the strain which was propagated has been reproduced, as far as can be determined from trees of their age. Each year since that time several thousand trees in various citrus orchards in California have been budded or top-worked on the same basis, and those which have reached bearing age have reproduced the characteristics of the strain which was propagated.

CARE OF BUD WOOD.

Citrus bud wood should be used as soon as possible after it is cut from the select parent trees. If it is necessary to keep the bud wood for some time before it is used, it should be packed in moist, sterilized sphagnum moss and stored in a cool room having fairly uniform conditions of temperature and humidity. The ideal conditions for such a room are a temperature of about 70° F. and a relative humidity of 80 to 90 per cent. The moss used for packing the bud wood should be thoroughly moistened and sterilized with live steam for about an hour, after which it can be run through an ordinary clothes wringer in order to squeeze out all of the excess moisture. Under proper storage conditions citrus bud wood can be kept in good viable condition for several months.

BUDDING.

The most favorable time for budding is generally during the spring months. However, budding can be done successfully at any time during the growing period of the trees. With some varieties budding in the late fall is preferable to summer budding, as the buds will remain dormant in the stocks until the following spring and the young, tender growth of the buds will not be subjected to the extreme climatic conditions of the winter months. High budding—that is, the insertion of the buds as high on the stocks as possible—is recommended for California conditions.

In top-working undesirable trees, two or more of the main limbs should be selected as the foundation for the new head, as shown in figure 4. The select buds should be inserted in these limbs, two or more in each, about 1 to 2 feet from the trunk of the tree. After the buds have made a union with the tree, the limbs should be sawed off about 6 inches above the inserted buds. The freshly cut surfaces should be covered with grafting wax, pure lead paint, or some pruning compound, and the remainder of the tree should be covered heavily with whitewash, cloth, or other material, so as to protect the trunk and limbs of the tree from sun scald or other injuries due to exposure. After about a year's growth the limbs should be cut back again, so that only one bud is left on each. These second cuts should slope downward from a point directly above the bud union, and the surfaces should be again protected, so they will heal completely.

Top-worked trees should be inspected frequently for the first two or three seasons and all growth removed except that from the select buds. In one or two years the growth from such buds will begin bearing fruits and should reach normal production in from three to five years, depending on the variety and the climatic and cultural conditions.

SUMMARY.

Bud variation in citrus fruits is of more or less frequent occurrence and of great economic importance to citrus growers.

The investigations now under way indicate that undesirable bud variations can largely be eliminated from commercial citrus plantations by using bud wood from trees known to continuously produce fruit of the character desired. The determination of these trees is

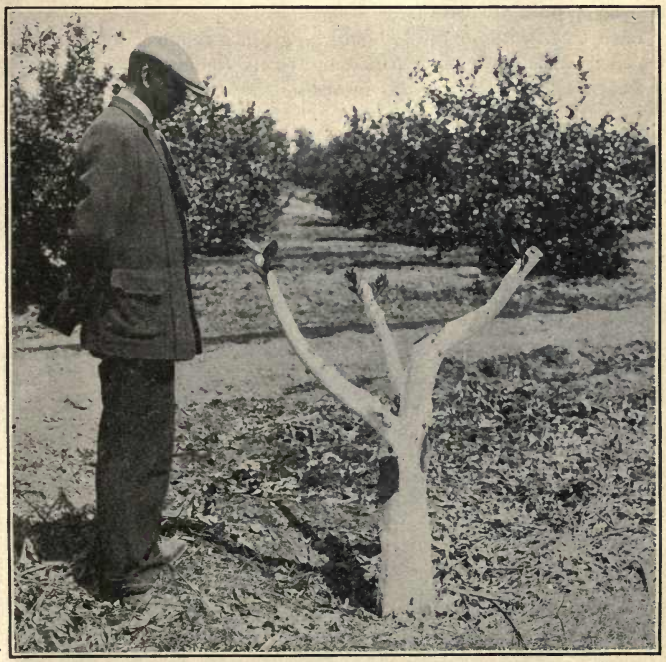

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FIG. 4.—A Eureka lemon tree of an unproductive strain 10 years old, rebudded to a productive strain, showing the first growth of the buds previous to the final cutting back of the foundation limbs.

most easily and satisfactorily made through the keeping of performance records.

Individual citrus-tree performance records are being kept by many citrus growers.

Records for an even number of successive seasons are desirable. For some purposes two seasons' records of full-bearing trees are

probably sufficient; in other cases four or more seasons' records ar preferable. The longer the period during which performance rec ords are kept and the greater the number of trees recorded, the mor valuable the records become.

These tree records enable the growers to locate good trees from which bud wood may be secured, poor trees to be top-worked with select buds, and trees needing individual care. They also provid reliable data on which to base conclusions concerning the results o tree or orchard treatments.

Each tree in the orchard should be given a number, by means o which it can always be identified and easily found.

The work of weighing and recording the crops of the individua trees can be done with little extra expense by adding one laborer t each picking crew. This cost is small when considered in connec tion with the value to the grower of the information obtained thereby.

Only fruit-bearing bud wood should be used in propagation. This bud wood can be used immediately after cutting, or it can be kept in moist, sterilized moss in a cool room for several months.

The spring period of tree growth is usually the best time for budding.

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